

Amendments to the Specification:

Please replace paragraph [0003] with the following amended paragraph:

[0003] Integral components of such devices are ~~[[the]]~~ electrodes (i.e., anodes and cathodes), which ~~[[that]]~~ should have a surface that is as large as possible in order to achieve optimal reaction conditions for the conversion processes.

Please replace paragraph [0004] with the following amended paragraph:

[0004] The conventional production of the electrodes occurs through the use of thin metal foils or by the compacting of powders, preferably by coating of the powdery reactants on current collectors. ("Elektrochemische Stromquellen", K. Wiesener, I. Garche, M. Schneider, Publisher Akademie Verlag, Berlin 1981). In this so-called "liquid coating", the respective materials for the anode and cathode are suspended in solutions of polymer binders and then applied to current collectors (Al, Cu or the like) as thin films. The solvent(s) is (are) drawn off in ~~[[the]]~~ a drying tunnel and the anode and cathode – if ~~necessary~~ necessary, provided with a separator – are encapsulated to form the battery. In the production of rechargeable batteries, in particular Li-batteries, the production of the thin electro-strips (anode or cathode) and the arrangement of the separator are of particular importance in order to optimally realize the diffusion of the reactants (in particular conducting salts). (Varta Report 1/96 – Rechargeable Li-batteries).

Please replace paragraph [0006] with the following amended paragraph:

[0006] Consequently, the object according to the invention consists ~~in~~ of providing a method for the production of battery electrodes and battery electrodes produced with this method that solve the aforesaid problems of the state of the art. In detail, the object of the invention comprises the provision of a method that does not require organic solvents in the production of the battery electrodes and may provide battery electrodes with an increased inner surface, as well as battery electrodes produced with this method.

Please replace paragraph [0007] with the following amended paragraph:

[0007] ~~This The objects are~~ object is solved by the characteristics of the independent claims 1 and 20. Further aspects of the object according to the invention are solved by the characteristics of the independent claims 2 to 19 and 21. one embodiment of the present invention, which includes a method for the production of an extruded electrode material for use in a battery. The method includes extruding a cathode material composition or an anode material composition. The cathode material composition or the anode material composition includes an isocyanate and an aqueous dispersion of a polymer binder. During extrusion, the isocyanate reacts with the aqueous dispersion of a polymer binder to form an extruded electrode material having a porous structure. Another embodiment of the present invention includes a battery wherein the extruded electrode material having a porous structure is used to create an anode, cathode, and/or separator of the battery.

Please replace paragraph [0008] with the following amended paragraph:

[0008] According to the method according to the invention for the production of battery electrodes, an electrode material is produced and from this electrode material, a cathode or an anode are formed, whereby the electrode material comprises isocyanate and an aqueous dispersion of a polymer binder which react with one another, preferable with the water of the dispersed polymer binder in order to form porous, in particular open-porous structures. In addition, where appropriate, a separator material is produced that is also extruded as subsequently described.

Please replace paragraph [0011] with the following amended paragraph:

[0011] The porous structure of the anodes or cathodes is a characteristic of the invention and is generated through chemical reaction of the isocyanate groups with reactants, preferably with the water of the dispersed polymer binder. Through the quantity and nature of the isocyanate groups-containing systems (di-, tri-, and/or polyisocyanate) as well as the process control in the extruder (temperature, residence time, dosing of the polymer binder dispersion – speed and dosing arrangement -), the pore structure, i.e. the inner surface of the electrode materials, may be

adjusted in a defined way. Information about isocyanates ~~is to~~ can be gathered from Kunststoff-Lexikon 9th Edition pp. 252/253 1998 and from Ullmann's Encyclopedia of Industrial Chemistry Vol. A 21, 665-711, 1992 Publisher Verlag Chemie Weinheim.

Please replace paragraph [0015] with the following amended paragraph:

[0015] A: ~~[[As]]~~ For anode materials, the materials mentioned in Ullmann's on page 1 (l.c.) are to be ~~considered, which~~ considered. The anode materials can include intercalatable carbon such as graphite or mesocarbon microbeads. The anode materials are added to an isocyanate, preferably a di-, tri- or polyisocyanate. The quantity of the isocyanate is preferably 0.5 – 10 percent by weight based on the electrode material. If necessary, further polymers as powders or fine-grained granulate may be used, preferably in quantities of 0.1 – 10 percent by weight. The polymers are e.g. polyolefins, polyethylene, polypropylene, polyisobutene, polystyrene, rubbers on the basis of styrene/butadiene or isoprene or also fluoroelastomers, preferably terpolymers on the basis of TFE (tetrafluoroethylene), HFP (hexafluoropropylene), and VDF (vinylidene fluoride). The components are mixed, e.g. in a Voith-mixer, preferably at temperatures between 20 and 80 °C.

Please replace paragraph [0016] with the following amended paragraph:

[0016] A1: The mixture A is fed to an extrusion system (Collin 136/350 or E IGT or the like). The extruder (compare Collin-company magazine: Extrusion systems) preferably comprises the following devices: throttle valves for the adjustment of the throughput, adjustable slit ~~widths~~ die (with adjustable thickness and width), continuously variable heating, dosing (gravimetrically or volumetrically controlled), parallel rotating or counter rotating twin screws, and a degasification nozzle.

Please replace paragraph [0017] with the following amended paragraph:

[0017] The extrusion is preferably carried out at temperatures of 80 to 180 °C (measured, e.g., at a discharge slit die of the extruder), preferably at temperatures of 120 to 140 °C. Temperatures of 80 to 100 °C (measured, e.g., at a feed zone of the extruder) may also be set. The aqueous

dispersion (e.g. Dyneon THV[®]) of the polymer binder may be introduced in the feed zone via a dosing pump, for example at temperatures of 20 to 100 °C. The quantity of the metered polymer dispersion is preferably 1-15 percent by weight (based on the entire anode material).

Please replace paragraph [0018] with the following amended paragraph:

[0018] A2: The anode material that discharges e.g. from the slit die, (width of the slit die of 30 – 500 µm, preferably 10 – 400 µm), µm; thickness of the slit die of 5 to 1,000 µm, preferably 10 – 400 µm, µm; temperature at the slit die of [[e.g.]] 110 – 180 °C, preferably 120 – 140 °C, 140 °C), may be brought together with a current collector strip (“current collector”) made of metal, e.g. Cu-foil, and laminated (laminating pressure typically up to 100 bar, preferably 2 – 10 bar). Through the reaction of the isocyanate, the The discharging anode material is ~~through the reaction of the isocyanate~~ preferably open-porously structured and is pressed to the desired thickness or porosity through the pressure exerted during lamination to the current collector.

Please replace paragraph [0019] with the following amended paragraph:

[0019] The processes B, B1, and B2 for the cathode ~~occur analogously~~ are analogous to the processes A, A1, and A2 for the anode. However, the material used for the cathode can include an intercalatable metal oxide such as an oxide of Mn, Ni, Co, Ti, Cr, Mo, or W.

Please replace paragraph [0020] with the following amended paragraph:

[0020] Compounds generally known in the art can be used ~~are considered~~ as isocyanates in the present invention. Especially preferred are isophorone diisocyanate, 1,4-cyclohexane diisocyanate, Uretidon-Desmodur TT^R; TT[®], Prepolymer-Desmodur VP-PU 0137^R; 0137[®] (a reaction product of poly(butene adipate) and a mixture of 65 % toluene 2,4-diisocyanate and 35 % toluene 2,6-diisocyanate, naphthalene 1,5-diisocyanate and the like which are preferably premixed with the respective anode or cathode material.

Please replace paragraph [0022] with the following amended paragraph:

[0022] Suitable as polymer binder dispersion are aqueous dispersions with nonionic emulsifiers

or salts of perfluorocarboxylic acids, preferably with a number of carbon atoms of more than 6, and polymers on the basis of fluoropolymers, in particular co- or terpolymers, e.g. Dyneon THV[®], THV[®].

Please replace paragraph [0024] with the following amended paragraph:

[0024] Production of a cathode material: 2,600 parts LiCoO₂ SS5[®] SS5[®] [[are]] were mixed (using a Voith-mixer, at room temperature, for 60 minutes) with 300 parts Ensaco 200[®] 200[®] (a conducting carbon black from)-(Erachem) as well as 50 parts Desmodur 15[®] (naphthalene 1,5-diisocyanate from)-(Bayer). This and this mixture [[is]] was fed into a Collin-extruder that [[is]] was operated at an internal temperature of 100 – 110 °C, simultaneously. Simultaneously, 1,500 parts of an aqueous dispersion (35 %) of a terfluoropolymer (THV Dyneon 120 D[®]-(from 3M) [[are]] were fed into the extruder, that has which had a degasification nozzle, via a dosing pump. With After a residence time of 1 – 3 minutes in the mixing area of the extruder, the material [[is]] was removed via a slit die (150 mm wide, thickness of the slit 15 µm). The material discharges discharged as a continuous film and [[has]] had a thickness of 25 – 40 µm, the µm. The discharging discharged cathode material [[is]] was applied to a prime coated Al-foil and dried in a drying tunnel at 150 – 180 °C. The properties and mode of action of these electrodes in a Li-polymer battery are shown in the following table.

Please replace paragraph [0025] with the following amended paragraph:

[0025] Polyisocyanate and binder [[are]] were fed in as a dispersion. The production of the cathode material in this example In case it is was operated as described in example 1, however except without isocyanate in the mixture, but with a polyisocyanate dispersion aqueous 40 % (100 parts) that [[is]] was combined with 1,300 parts of the aqueous polymer dispersion (analogous to example 1) and simultaneously dosed into the extruder, a extruder. A cathode material [[is]] was obtained that [[has]] had a thickness of 30 – 45 µm and [[is]] was also dried in the drying tunnel at 120 – 185 °C. As with the cathode material produced in example 1, this This material [[shows]] showed an open-porous structure-as-well. The properties and mode of action of these electrodes in a Li-polymer battery are shown in the following table.

Please replace paragraph [0026] with the following amended paragraph:

[0026] Production of an anode material: 2,800 parts of synthetic graphite MCMB 25/28^R 25/28[®] ~~[[are]] were~~ mixed as described in example 1 with 150 parts ~~conducting carbon black~~ Ensaco 250^R 250[®] (a conducting carbon black) as well as 40 parts ~~MdI-Desmodur^R~~ MdI-Desmodur[®] (4,4'-methylene diphenyl diisocyanate) and dosed in a ~~Collin-extruder in which simultaneously~~ Collin-extruder. Simultaneously, 1,500 parts of a 35 % aqueous polymer dispersion (analogous to example 1) ~~[[are]] were~~ pumped into the extruder. As in example 1, a material ~~[[is]] was~~ also extruded here that ~~[[has]] had~~ a thickness of 25 – 45 ~~µm and µm~~. The material was ~~[[is]] was~~ continuously laminated to a Cu-foil and subsequently dried in the drying tunnel at 120 -180 °C. ~~(120—180 °C)~~. The structure of the material ~~[[is]] was~~ porous; the residual moisture ~~[[is]] was~~ < 20 ppm. The properties and mode of action of these electrodes in a Li-polymer battery are shown in the following table.

Please replace paragraph [0027] with the following amended paragraph:

[0027] ~~Analogous~~ This example is analogous to example 3, however with ~~except that it also included a polyol diisocyanate from TDI^R TDI[®] and poly(tetramethylene glycol) 40 parts (ratio TDI to glycol 1:1). In this case as well~~ As in example 3, an anode material ~~[[is]] was~~ obtained from the slit die of the extruder that ~~discharges~~ discharged with a thickness of 30 to 50 µm, ~~[[is]] was~~ laminated to Cu-foil, ~~had Cu-foil and has~~ residual moisture after drying of < 20 ~~ppm ppm~~, and ~~[[has]] had~~ an open-porous structure. The properties and mode of action of these electrodes in a Li-polymer battery ~~[[is]] are~~ shown in the following table.

Please replace paragraph [0028] with the following amended paragraph:

[0028] Production of a composite of an anode and a cathode with a separator as intermediate layer. The anode (example 3) and the cathode (example 1) ~~[[are]] were~~ provided with an intermediate layer ~~e.g. Cellgard^R~~, namely (e.g., Cellgard[®]) in such a way that the ~~Cellgard~~ the intermediate layer was ~~[[is]]~~ introduced between the anode and the cathode so that the current collectors ~~[[are]] were~~ the outer layer of the composite system. Before the laminating of the anode, the intermediate layer (~~Cellgard~~) and the cathode, the films ~~[[are]] were~~ moistened with a

1 molar solution of LiPF_6 in ethylene carbonate, diethylene carbonate, and dimethyl carbonate (1:1:1), in each case 1,500 g onto 5,000 g of the total ~~mass; after the~~ mass. The moistening, which this corresponds to soaking of the porous materials with the electrolyte, was performed ~~[[and]]~~ at temperatures of 20 – 120 °C and pressures of 1 – 100 bar (corresponding to 0.1 mPa to 10 mPa). The composite system ~~[[is]]~~ was then conventionally processed into prismatic or winding cells and ~~[[is]]~~ was complete after housing and poling (i.e. contacting of the anode or cathode end faces with the positive or negative pole of the ready-to-use ~~battery; battery~~). The properties and mode of action of these electrodes in a Li-polymer battery ~~[[is]]~~ are shown in the following table.

Please replace paragraph [0029] with the following amended paragraph:

[0029] Production of a cathode material with aqueous polymer dispersion but without isocyanate additive. ~~In case it~~ This example was ~~[[is]]~~ operated according to example 1 without addition of ~~Desmodur^R; a Desmodur®~~. A film, which was ~~[[is]]~~ obtained under an otherwise identical process operation as described in example 1 had, that on discharging from the extruder die, has a thickness of 15 – 30 µm and, after drying, a moisture of < 20 ppm. The properties and mode of action of these electrodes in a Li-polymer battery ~~[[is]]~~ are shown in the following table.

Please replace paragraph [0030] with the following amended paragraph:

[0030] Production of an anode material without isocyanate additive. ~~In case it~~ This example was ~~[[is]]~~ operated according to example 3, however except without the addition of the ~~MdI-Desmodur^R; MdI-Desmodur®~~. A film, which was ~~it is also obtained a film;~~ under otherwise identical operating conditions as described in example 3 had, that on discharging from the extruder die, has a thickness of 18 – 25 µm and, after drying, a moisture of < 20 ppm. The properties and mode of action of these electrodes in a Li-polymer battery ~~[[is]]~~ are shown in the following table.

Please replace paragraph [0032] with the following amended paragraph:

[0032] In a Collin-extruder, 200 parts of a prepolymer on the basis of poly(tetramethylene glycol), molar mass 5 – 10,000, and ~~MDi^R~~ MDI® as a co-reactant ~~[[are]]~~ were metered (weight ratio of polyol to MDi ~~weight of~~ 1:1), and 1,500 parts of a 50 % dispersion comprising 600 parts

of Dyneon ~~THV^R~~ THV® and 150 parts of conducting carbon black ~~Ensaco^R~~ (Ensaco®) as well as a slurry of 100 parts of MgO/Al₂O₃ (weight ratio of 1:1) in 500 parts of water ~~[[is]]~~ was dosed. ~~[[The]]~~ Operating the extruder ~~operates~~ at temperatures of 100 °C - 120 °C, part of the water ~~[[is]]~~ was withdrawn via a degasifying nozzle. A porous material ~~that was is-discharging~~ discharged from the die of the extruder ~~that is was~~ removed via release paper and dried at 120 – 180 °C. The obtained film ~~[[has]]~~ had a thickness of about ~~[[~]]~~ 30 µm and after drying a water content of < 20 ppm. The film ~~[[is]]~~ was suitable as an intermediate layer between the anode and the cathode of ~~for the composite system with anode and cathode since~~ because its porosity ~~allows~~ allowed the take-up of electrolytes, and because it ~~[[is]]~~ was sufficiently resistant to tearing and elastic for a further continuous processing process.

Please replace paragraph [0034] with the following amended paragraph:

[0034] The composite of anode/separator and cathode produced according to the examples ~~[[is]]~~ was rolled into a winding and contacted via the winding face surfaces, + poled -, and then installed. The winding diameter ~~[[is]]~~ was 8.2 cm, the charging (galvanostatic) ~~occurs~~ occurred by means of a Digatron-charger stepwise from 3.0 via 3.6 and then up to 4.2 Volt; in each case with currents of 0.15 mA/cm².

Please replace paragraph [0036] with the following amended paragraph:

[0036] Winding cells were produced from:

		<u>Discharge capacity A</u>
1)*	Cathode material <u>according to example 1</u> + Anode material <u>according to example 3</u>	<u>Discharge capacity A</u> 52
2)*	Cathode material <u>according to example 2</u> + Anode material <u>according to example 4</u>	54
3)*	Cathode material <u>according to example 6</u> + Anode material <u>according to example 3</u>	62
4)*	Cathode material <u>according to example 2</u> + Anode material <u>according to example 7</u>	60

* In each case with the separator material according to example 8

5) Cathode material according to example 1 52
+ Anode material according to example 3
With Cellgard® as separator

6) Cathode material according to example 1 52
+ Anode material according to example 3
With Solupor as separator

7) Cathode materials or anode materials ~~[[are]]~~ were not produced with the method according to the invention but through extrusion of the equivalent quantities of fluoroelastomers, thus without isocyanate additives and not as aqueous ~~dispersions, that~~ dispersions. As a result ~~way~~, discharge capacities between 35 and 40 Ah ~~[[are]]~~ were obtained under analogous conditions (7a, 7b), e.g.:

7a. Cathode material according to example 1 except without diisocyanate and with 525 parts perfluoropolymer THV Dyneon 120®
+ Anode material according to example 3 except without diisocyanate and (as above) with 525 parts of THV Dyneon 120® with a separator according to example 8.

7b. like 7a, but with Cellgard® as the separator.